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10/530,134	06/09/2005	Toru Hayashi	JFE-05-1040	9923

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EXAMINER	
SHEVIN, MARK L	

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1793	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 10/530,134	Applicant(s) HAYASHI ET AL.	
	Examiner Mark L. Shevin	Art Unit 1793	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *08 January 2008*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-16* is/are pending in the application.

4a) Of the above claim(s) *10-16* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-9* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

DETAILED ACTION

Status

1. Claims 1-16, filed as an amendment on 8 January 2008, are pending. Claims 10-16 are still held are withdrawn from consideration.

Amendments to the Specification

2. The amendments to the specification, filed 8 January 2008, show no new matter and are thus entered.

Response to Applicants' Arguments

3. Regarding claim 1, Applicants asserts that Kurita does not mention a "ferrite-cementite" structure or a "ferrite-cementite-pearlite" structure. However the Examiner disagrees in that pearlite, as a microstructure is inherently a mixture of ferrite and cementite phases and thus Kurita does implicitly teach a "ferrite-cementite" structure. After all, Applicants' specification states that a ferrite-cementite structure does not impair the present invention (p. 15, para. 3) so there is a question of criticality as well.

In this vein, Cunnigham (J.L. Cunningham, et al. Effects of Induction Hardening and Prior Cold Work on a Microalloyed Medium Carbon Steel, *Journal of Materials Engineering and Performance,* (1999), Vol 8, p. 401-408.) teaches that microalloyed (V, Nb, or Ti additions) medium carbon steels gain their strength from the precipitation of carbonitrides and that strengths typical of highly tempered martensitic steels are obtained by pearlite formation and precipitation strengthening. Because the strengthening effects are exhibited in the direct-

cooled, ferritic-pearlitic microstructures, heat treatment subsequent to rolling or forging is not necessary.

4. Furthermore the claimed steels are argued as having a rotating bending fatigue strength of 800 MPa or more, but this limitation is nowhere in the claims. The preamble of the claims lays out “a high strength steel having high fatigue strength” however a qualitative limitation such as high-strength and high-fatigue do not impart any additional structure to the claims above and beyond the microstructure and composition limitations.

5. Looking to Col. 4 beginning at line 32, the Examiner reads the warning about avoiding martensite and bainite as applying only to the microstructure in the core of the material, not the outer layer. This is because the paragraph at Col. 4, line 32 begins by saying “In a nitrided steel part, bending toughness is also closely related to the *core microstructure*."

6. Yoshida ‘337 is used as motivation to bring the grain size of the steel microstructure of Kurita down to below 7 microns in calling for a grain size number of 7 or higher. Yoshida ‘337 is analogous in that he teaches power transmission shafts and methods of increasing the strength of them (Col. 1, lines 37-41). Yoshida ‘337 is teaching that the grain size is a result effective variable, and that in decreasing the grain size (increasing the grain size number), one avoids quenching crack sensitivity (Col. 2, line 60 to Col. 3, line 2).

7. Regarding Yoshida ‘337 as a graphite steel, even if the microstructure becomes a solid solution of graphite with ferrite, Yoshida ‘337 still teaches, in claim 2, a power transmission shaft where the ferrite grain size number of the

portion of the carbon steel where the thermal effect (induction hardening) has not reached is 7 or higher. No matter what is said about the unsuitable of graphite as a result of quench hardening, Yoshida '337 used the steel article are a power transmission shaft and constant velocity joint (4-7), applications that require high-strength and high-fatigue. Yoshida '337 need not teach the ferrite-cementite or ferrite-cementite-pearlite structure as Kurita was already argued to do just that.

8. Regarding claim 2, Applicants assert that Kurita teaches away from adding molybdenum to the alloy. The Examiner disagrees in that stating "Mo may not be added" means that molybdenum is not necessary to Kurita's invention and thus does not teach away from the additional of molybdenum. In fact Kurita teaches the benefit of Mo additions of between 0.01 and 0.30 percent in that it has the effect of improving toughness (Col. 6, lines 45-52).

9. Regarding claims 4 and 9, Yoshida '924 is introduced to reject claims 4 and 9 as Yoshida '924 discusses steel compositions for power transmission shafts where the cementite present in the structure is converted to graphite through annealing, allowing the product to have a greater strength and fatigue resistance (Col. 3, lines 1-19). Neither Yoshida '924 nor Yoshida '337 need teach or suggest all of applicant's claimed invention. Yoshida '924 suggests that the cementite content of a steel prior to induction hardening is a result effective variable and furthermore cementite (and the related carbon content) is necessary to form martensite on the surface layer (Col. 3, lines 1-17). Furthermore, Yoshida '924 addresses some of the issues that Applicants had argued regarding the induction quenching of graphite. Yoshida '924 teaches that the strength can

be balanced and prevented from decreasing by controlling the grain size of the graphite steel (Col. 4, lines 10-20).

10. Regarding claims 5 and 6, Applicants have amended claim 5 to have a prior austenite grain size limitation of 5 microns (down from 12 microns) or less. Ochi still is effective is establishing a prima facie case of obviousness in that Ochi teaches the range of 8.8 microns and smaller (assuming roughly circular grains) as he discloses limiting the prior austenitic grain size number to above 9. Applicants' claimed range of 5 microns and smaller still overlaps with Ochi's range of ~8.8 microns and smaller. The reason why the grain size in the above range can further improve the strength properties of the shaft is as follows: The tensile strength and torsional fatigue hardness of the shaft are influenced by the intergranular strength of the former austenite. The finer the grains, the smaller the amount of impurities segregated within grain boundaries and the better the intergranular strength.

11. Regarding claims 3, 7, and 8, Applicant does not argue these rejections, only the claims on which they depend and as such the previous rejections still stand.

12. **Claims 1-3, 7-8** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Kurita** (US 6,083,455) in view of **Yoshida** (US 6,319,337).

Regarding claim 1, Kurita teaches a steel product having a high tensile and fatigue strength, excellent bending toughness with a ferrite-pearlite microstructure. Table 1 discloses a number of steel alloys of Kurita's invention that fall within the claimed composition range. For example, see steel Z5 (weight

percent), with carbon: 0.39%, silicon: 0.05%, manganese: 0.42%. Kurita does not teach that the grain size must be 7 microns or less.

Yoshida teaches the if ferrite grains in a steel structure are too large, quenching crack sensitivity increases remarkably and therefore ferrite grain size number (JIS G0552, see Table A below) of the carbon steel should be 7 or higher (col 2, lines 60-64). *The Examiner interprets 'grain size' to mean average grain diameter.* Assuming roughly uniformly distributed and round grains, the 7 micron or less limitation of claim 1 works out to a JIS grain number of 10 or higher (the higher the grain number, the finer the grains). Thus the current limitation is within the range taught (and claimed in claim 2) by Yoshida as favorable in avoiding crack sensitivity.

TABLE A-continued

JIS Grain Size Classification

Grain Size Number (N)	Number of Crystal Grains in Area of 1 mm^2 (n)	Average Sectional Area of Crystal Grain (mm^2)
5	256	0.00390
6	512	0.00195
7	1024	0.00098
8	2048	0.00049
9	4096	0.000244
10	8192	0.000122

It would have been obvious to one of ordinary skill in the art at the time the invention was made to combine Kurita in view of Yoshida as Kurita teaches favorable compositions and microstructure for steels used in a power transmission role and Yoshida teaches how to refine the microstructure further by limiting the grain size. The particular limitation of 7 microns or less is, on its face,

the result of the optimization of processing conditions in the course of routine experimentation. Material science and metallurgy in particular is focused in large part of the effect of grain size.

Regarding claim 2, Kurita teaches that molybdenum, if added, has an effect of improving toughness but that molybdenum is saturated at 0.30% (col 6, lines 46-52). Kurita also demonstrates a few steel compositions in the claimed C, Si, Mn, and Mo range in Table 3, see Steels 4 and 9 for example.

Yoshida also teaches that adding 0.4 or lower weight percent of Mo improves hardenability and that above 0.4%, the effect of hardenability reaches a plateau (col 3, lines 24-27).

Regarding claim 3, Kurita teaches a steel that meets the composition limitations of claims 1 and 2 and further includes aluminum in the claimed range, see Steels 11 and 14 in Table 3.

Regarding claim 7, Kurita teaches nitriding is carried out through "gas nitriding" where hot gas is passed by the steel product for many hours to diffuse nitrogen into the surface (col 9, lines 23-36) and the ferrite grain size could be controlled by the optimization of process conditions in the course of routine experimentation. This size could be adjusted by using a precursor steel with a smaller outer ferrite grain size before nitriding.

Regarding claim 8, Kurita teaches a steel that meets the composition limitations of claims 1 and 2 and further includes aluminum in the claimed range, see Steels 11 and 14 in Table 3.

13. <u>**Claims 4 and 9**</u> are rejected under 35 U.S.C. 103(a) as being unpatentable over **Kurita** (US 6,083,455) in view of **Yoshida** (US 6,319,337) as applied to claims 1-3 above, and further in view of **Yoshida** (US 6,390,924). What Kurita and Yoshida '337 teach was discussed in the 103 rejection to claim 1 above, however neither reference explicitly teaches how much of the cementite phase one should have in a favorable high-strength, high fatigue strength steel.

<u>Regarding claims 4 and 9,</u> Yoshida '924 discusses steel compositions for power transmission shafts where cementite content in the steel in converted to graphite through graphitization annealing allowing the product to have more residual compressive stress on the surface, resulting in greater strength and fatigue resistance (col 3, lines 1-19).

It would have been obvious to one of ordinary skill in the art to combine Yoshida '924 with the previously established combination of Kurita in view of Yoshida '337 to include more than 4 volume percent cementite as Yoshida '924 implies that this cementite can be transformed into graphite and then martensite to yield a product with higher strength and higher resistance to fatigue. The particular limitation of 4 volume percent is on its face the result of the optimization of ranges in the course of routine experimentation as one would vary the amount of cementite phase present in a steel product depending on the properties required on the final, finished product.

14. <u>**Claims 5 and 6**</u> are rejected under 35 U.S.C. 103(a) as being unpatentable over **Kurita** (US 6,083,455) in view of **Yoshida** (US 6,319,337) as applied to claims 1-3 above, and further in view of **Ochi** (US 5,545,267). What

Kurita and Yoshida '337 teach was discussed in the 103 rejection to claim 1 above, however neither reference explicitly teaches what the grain size of the prior austenite grains should be after induction quenching.

Regarding claim 5, Ochi teaches how one would more preferably go about hardening a steel shaft for excellent torsional strength by induction heating the steel such that the grain size number of the prior austenite grains in 9 of more, which under the same assumptions of claim 1 regarding grain geometry, corresponds to grain sizes of approximately 8.8 microns or less, which is within the claimed range. (Col 8, lines 34-42). Ochi teaches that if the prior austenite grains are any larger (smaller grain size number) then the effect of preventing the brittle facture caused by intergranular fracture is small (col 8, lines 40-45).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to combine Ochi with the combination of Kurita in view of Yoshida '337 established in the 103 rejection to claim 1 above to produce a steel product with a martensite surface layer having prior austenite grain sizes less than 12 microns as Ochi taught the advantages of limiting the prior-austenite grains in terms of preventing brittle fracture. Furthermore induction hardening is well known to produce martensite and harden the surface of steel as evidenced by the ASM Handbook (Volume 1: Properties and Selection, Irons, Steels, and High Performance Alloys, *Fatigue Resistance of Steels* edited by B. Boardman, copyright 1997).

Regarding claim 6, Kurita teaches a steel that meets the composition limitations of claims 1 and 2 and further includes aluminum in the claimed range, see Steels 11 and 14 in Table 3.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

-- Claims 1-9 are *finally rejected*
-- Claims 10-16 remain withheld
-- No claims are allowed

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Mark L. Shevin whose telephone number is (571) 270-3588. The examiner can normally be reached on Monday - Thursday, 8:30 AM - 5:00 PM EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Roy M. King can be reached on (571) 272-1244. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

/Mark L Shevin/
Examiner
Art Unit 1793

/Vickie Kim/
Supervisory Patent Examiner, Art Unit 4116